(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
17 July 2003 (17.07.2003)

PCT

(10) International Publication Number
WO 03/057344 A1

(51) International Patent Classification[7]: B01D 25/12

(21) International Application Number: PCT/FI03/00009

(22) International Filing Date: 8 January 2003 (08.01.2003)

(25) Filing Language: Finnish

(26) Publication Language: English

(30) Priority Data:
20020023 8 January 2002 (08.01.2002) FI

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(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

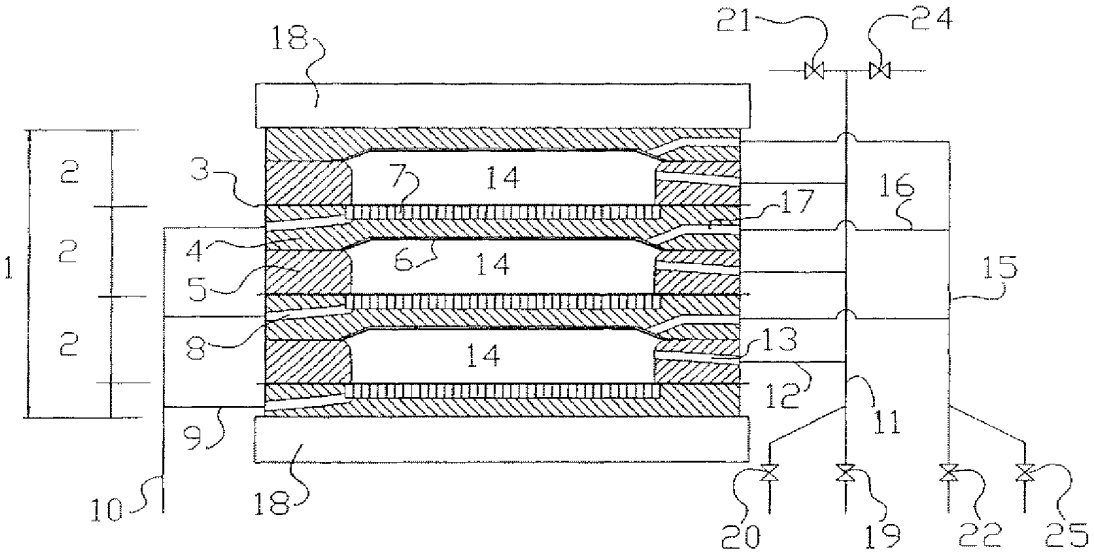
(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:
— *of inventorship (Rule 4.17(iv)) for US only*

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) **Title:** METHOD AND APPARATUS FOR CONTROLLING THE FORMING OF A CAKE IN A FILTER PRESS



(57) **Abstract:** The invention relates to a method and apparatus for controlling the formation of a filter cake (23) particularly in the filter chamber (14) of a pressure filter. The essential feature of the invention is that the formation of the filter cake during filtration is controlled by means of adjusting the squeeze pressure applied to the cake.

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Method and apparatus for controlling the forming of a cake in a filter press.

The present invention relates to a method according to the preamble of claim 1 for controlling the formation of a filter cake in the filter chamber of a pressure filter.

Automatic pressure filters are widely used in the mining and process industries for separating the liquid fraction and the solids fractions of a slurry/sludge from each other.

Typically, an automatic pressure filter comprises a filter plate assembly consisting of a stack of filter plates having identical filtration properties. Between the filter plates is draped a long endless loop of filter cloth or the like material running in a zigzag fashion between the plates, whereby the particulate matter accumulate on the cloth during filtration so as to form a filter cake. The top surface of each filter plate is covered by a drain screen or the like structure that supports the filter cloth resting thereon during filtration so as to allow nevertheless an unobstructed drainage of the filtrate fraction permeated through the cloth to outside the filter plate stack. On the underside of the filter plate is provided an interplate filtration space of uniform height and sealed at its edges with dimensions that covers almost the entire area of the filter plate and into which the slurry to be filtered is pumped. The upper part of the space is generally covered by a flexible diaphragm such as a rubber sheet, for instance, whereby the drained filter cake can be further dried under squeeze pressure accomplished by way of passing a pressurized medium (water, air, etc.) above the sheet. The operating principle of the filter described here is disclosed, e.g., in patent publication US 3,342,123.

In the beginning of a typical filtration cycle in this type filter, a clamping device presses the filter plates tightly against each other between pressure plates thus forming filter chambers in the closed stack of plates. Next, the slurry/sludge suspension to be filtered is pumped into each filter chamber, whereby the solids fraction remains on the surface of the filter cloth while the filtrate is drained through the filter cloth and passed out from the filter.

After the slurry/sludge is pumped into the filter, on the top side of the flexible diaphragm is passed a pressurized medium that imposes via the diaphragm a mechanical squeeze compression on the filter cake thus reducing its moisture content. At the end of the squeeze phase, the compressive force is removed and compressed air or the like pressurized gas is passed through the filter cake in order to reduce its moisture content. When necessary, the filter cake may also be washed by passing one or more kinds of washing liquid therethrough.

After all the filtration steps have been completed, the clamping device opens the plate stack, whereby the filter plates remain hanging by their support eyelets at a predetermined distance from each other. The filter cakes are discharged on different sides of the filter when the endless filter cloth belt starts to move actuated by a conveyor apparatus supporting the filter cloth.

In this kind of a filter, the separation of the liquid phase from the solids can be performed effectively inasmuch as the pressure levels and durations of the different filtration process steps can be adjusted optimal for the slurry/sludge being filtered.

For some suspensions, however, such as titanium dioxide, starch and calcium carbonate slurries (PCC, GCC), for instance, the filter cake formed in filtration tends to crack after the compressive squeeze pressure is released. Hereby, the drying air intended to travel uniformly through the entire bulk of the filter cake can escape via the cracks of the cake thus annihilating the desired drying effect. The same may also happen in conjunction with the washing of the filter cake, whereby the washing liquid travels via the cracks of the cake without effecting the desired washing result.

If a predetermined solids content or washing result is specified, it may be necessary to use a multiple amount of drying gas or washing liquid as compared with a situation having a crack-free cake.

As disclosed in patent publication JP 59-088348, the escape route of drying air and/or washing liquid via the cake cracks can be blocked by way of, e.g., pumping at the end of the squeeze phase onto the cracked cake an additional

layer of sludge that plugs the cracks. However, one of the drawbacks of this method is a longer duration of the filtration phase that respectively reduces the filtration capacity of the filter.

Alternatively, the cracking of the filter cake may also be counteracted by mixing chopped fiber, cellulosic pulp, diatomaceous earth or the like material with the sludge. In many cases this approach is not acceptable inasmuch as all the solids contained in the sludge is desired to be recovered. This method is also hampered by significant extra costs from the use of such additives.

As disclosed in patent publication JP 57-136463, the cracking of the filter cake may also be counteracted by pumping a fibrous substance mixed with the sludge onto the filter cake.

In this kind of pressure filter, the squeeze pressure applied on the diaphragm also forces solids into the sludge inlet channel of the filter plate, although it is customary to flush the inlet channel with water prior to starting the filter cake squeeze with the help of the flexible diaphragm. When the cake squeeze pressure is released and the drying step with air is commenced, the pressure of the drying air releases the solids plug from the sludge inlet channel and pushes it ahead into the filter chamber. In practice, however, the solids plugs do not pop off exactly at the same time and, consequently, the drying air enters the chambers at different times. The transient pressure differentials thus occurring between chambers may set the filter plates into vibration that can invoke fatigue fracture in the filter plates.

It is an object of the present invention to provide a method capable of overcoming the disadvantages of the above-described prior art. The characterizing features of the invention are disclosed in the appended claims. The invention relates to both a method and apparatus for controlling the formation of a filter cake in the filter chamber of a pressure filter.

This invention relates to an arrangement for improving the filtration efficiency of a pressure filter by virtue of passing the substance to be filtered, such as a slurry/sludge, into a filter chamber, wherein the solids suspended in the slurry/sludge is collected on the surface of the filter cloth so as to form a filter

cake of desired type while the filtrate fraction passes through the filter cloth.

The arrangement according to the invention makes it possible to control the different properties of the filter cake. In particular, this novel technique is capable of effectively eliminating the cracking tendency of a filter cake formed in the filter thus facilitating efficient final drying of the cake and, when necessary, to permit the washing of the cake. The arrangement according to the invention also reduces the transient pressure differentials between the different filter chambers thereby minimizing vibrations imposed on the filter plate and eliminating the risk of fatigue failures.

In accordance with the invention, these benefits can be attained by controlling the internal pressure of the filter chamber with the help of a valve system. An essential feature in the method according to the invention is to perform the switch-over from the diaphragm squeeze phase to the air-drying phase or washing phase so that an overpressure as compared with the filtration phase is continuously maintained in the filter chamber. Resultingly, the filter cake formed into the filter chamber is kept under continuous squeeze pressure that hence prevents the cake from cracking. In accordance with the above description, an essential feature of the invention is that the formation of the filter cake during filtration is controlled by means of adjusting the squeeze pressure imposed thereon. In the context of this text the term "squeeze pressure" must be understood to refer to pressure or compressive force imposed on a filter cake by mechanical means or pressurized gas medium such a compressed air and/or pressurized liquid medium.

A further essential feature of the invention is an apparatus suited for performing the control operations of the present method. The apparatus comprises means capable of automatically controlling the compressive force applied to the filter cake.

More specifically, the characterizing features of the method and apparatus according to the invention are characterized by what is stated in the characterizing parts of claims 1 and 8, respectively.

The benefits of the invention will be better understood on the basis of the

following example.

Example

In tests performed, the solids content of PCC slurry was 55 % to 60 % at the end of the filtration cycle in conventional filtration. In contrast, filtration of the slurry by the method according to the invention achieved a solids content in excess of 65 %.

The above-mentioned advantage can be directly utilized in further processing of the cake. If the cake production of a filter is, e.g., 10,000 kg/h, the amount of water to be removed by thermal drying in the novel method is reduced by 1000 kg/h. Thence, the arrangement according to the invention makes it possible to contribute substantially to the efficiency of the entire filtration process thereby offering both economical and environmental benefits.

In the following, a typical embodiment of the invention is described in more detail by making reference to the appended drawings illustrating a filtration cycle according to the invention, in which drawings

FIG. 1 shows the cross section of a clamped filter plate stack during the pumping of slurry therein;

FIG. 2 shows the mechanical compression of the sludge in the filter chamber by means of a flexible diaphragm; and

FIG. 3 shows the reduction of moisture content of the thus formed filter cake with the help of air drying.

Referring to FIG. 1, a clamped filter plate stack 1 shown therein comprises a number of separate filter plates 2, having a filter cloth 3 draped therebetween. Typically, the filter plate 2 is formed by a bottom plate 4, a frame 5 and a flexible diaphragm 6, such as a rubber sheet, attached therebetween. The top surface of bottom plate 4 is covered by a drainage screen 7 that supports filter cloth 3 and thus facilitates the drainage of the liquid fraction, called the filtrate, separated from the slurry/sludge through the filter cloth into a drainage channel

8 situated at the top surface of the bottom plate 4 and therefrom further via a drainage hose 9 into a filtrate discharge pipe 10.

The sludge/slurry being filtered passes via an inlet pipe 11 into sludge inlet hoses 12 and further via channels 13 made in frame 5 into filter chambers 14. A squeeze pressure medium, generally pressurized water or air, is passed on the other side of squeeze diaphragms 6 via a pipe 15, hoses 16 and finally via channels 17 made in bottom plate 4.

In the beginning of a filtration cycle, the filter plates 2 are pressed against each other into a tight stack between massive head plates 18, whereby the valves of the piping system are controlled into their closed positions. Next, sludge inlet valve 19 is opened, whereby slurry/sludge to be filtered can flow into filter chambers 14. The liquid fraction of the sludge is passed via filter cloth 3 into discharge channel 8 and therefrom further out from the filter, while the solids are collected on the top surface of filter cloth 3. After a sufficient amount of solids has been collected into filter chamber 14, sludge infeed into filter chamber 14 is stopped by closing sludge inlet valve 19.

At this stage, the sludge inlet pipe 11 and sludge inlet hoses 12 are full of sludge that tends to settle and plug the piping system. Hence, this sludge must be removed from the piping by opening a discharge valve 20 and flushing water valve 21, whereby the pressure of the flushing water displaces the sludge from the sludge inlet pipe 11. Subsequently, discharge valve 20 is closed, whereby the high-pressure washing water ejects the sludge filling the hoses 12 into filter chamber 14. When the flushing water valve 21 is finally closed, the sludge inlet piping remains full of water.

Next, as shown in FIG. 2, squeeze pressure valve 22 is opened via which compressed air is passed into the space between squeeze diaphragm 6 and bottom plate 4. The expansion of diaphragm 6 forces the liquid fraction from the filter chamber through filter cloth 3 and squeezes the thus formed filter cake 23, whereby its moisture content is reduced. Typically, the maximum squeeze pressure in this type of filter is 16 bar, while in practiced the squeeze pressure is about 10 bar typical.

Prior to the end of the squeeze phase, sludge discharge valve 20 is opened, whereby the water filling hoses 12 and pipe 11 is discharged, while diaphragm 6 still continues to squeeze filter cake 23.

Subsequently, discharge valve 20 is closed and drying air inlet valve 24 is opened, whereby pressurized gas used for final drying of the cake flows via sludge inlet valve 11 and sludge inlet hose 12 into inlet channels 13. Generally, the gas used for drying is compressed air taken from the compressed-air supply of the plant at a pressure level of about 5 bar typical. Inasmuch as the squeeze pressure applied to the squeeze diaphragm is higher than the drying air pressure, the compressed air used for drying cannot enter filter chamber 14 at this stage.

Next, the squeeze pressure inlet valve 22 is closed and the level of the squeeze pressure is reduced gradually via valve 25. After the squeeze pressure has fallen substantially equal to the pressure of the drying air, the drying air begins to flow into filter chambers 14. Simultaneously, the drying air also begins to flow through the filter cake 23, whereby it elevates the squeeze diaphragms 6 toward the upper part of filter chamber 14. Resultingly, as shown in FIG. 3, at this stage the mechanical squeeze of filter cake 23 by means of diaphragm 6 has been replaced by squeeze under the pressure of the drying air. Having the filter cake thus continually kept under compression, it cannot shrink and cracking of the cake is avoided.

When the air-drying phase is completed, drying air inlet valve 24 is closed, whereupon the pressure of filter chamber 14 is released through filter cake 23 or, alternatively, can be discharged by opening discharge valve 20. Next, filter plate stack 1 is opened and filter cakes 23 are discharged with the help of the movable filter cloth 3 out from the filter in a conventional fashion as is disclosed, e.g., in patent publication US 3,342,123.

Accordingly, the above-described method makes it possible to keep the filter cake continuously pressed against the filter cloth, whereby cracking of the filter cake is prevented and the drying air is forced to pass uniformly through the entire cake.

In practicable pressure filter constructions, a logic control system takes care of opening/closing the actuator-driven valves, whereby the flow rate changes and pressure chocks in the filter can be very drastic. Transition from the diaphragm squeeze phase to the filter cake air drying or washing phase is the most critical moment in the control scheme of the method according to the invention. Namely herein a rapid discharge of the squeeze pressure medium from behind squeeze diaphragm 6 via valve 25 may cause an uncontrolled pressure fall on the top surface of the filter cake and, hence, cracking of the cake. This risk can be avoided by way of, e.g., using a controllable valve as discharge valve 25, whereby the removal of squeeze pressure from the opposite side of the diaphragm can be performed at a slow rate. An alternative approach illustrated in FIG. 3 is to mount in parallel with the actual discharge valve 25 a smaller valve 26 via which the squeeze pressure can be released at a very slow rate in the beginning of the squeeze pressure discharge phase. After the squeeze pressure has fallen below the pressure level of the applied drying air or washing liquid, diaphragm 6 ceases to press filter cake 23 and begins to rise toward the upper part of the filter chamber. Then, the actual discharge valve 25 can be opened for faster removal of the squeeze pressure.

In some cases the filtration process must be complemented with a filter cake washing phase in order to remove the initial liquid fraction of the sludge still contained in the cake as completely as possible. To minimize the amount of washing liquid needed, a major portion of the initial liquid content is removed from the cake solids by diaphragm squeezing. After the squeeze applied via the diaphragm is removed, certain types of filter cakes tend to crack thus allowing the washing liquid to escape via the cracks, whereby incomplete washing results. Such cracking of the cake can be avoided by controlling the feed of the washing liquid into the filter chamber in an analogous fashion with the control scheme of the air drying phase, that is, by starting the washing liquid feed phase into the filter chamber while the squeeze pressure is still being applied to the filter cake at the end of the diaphragm squeeze phase. After washing, the cake is generally subjected to another diaphragm squeeze phase followed by air drying that again is carried out using the method according to the invention.

In addition to the above benefits, the apparatus utilizing the control scheme according to the invention is free from essential pressure differentials between

the adjacent filter chambers that could abruptly bend a filter plate or cause fatigue failure in the long run.

To a person versed in the art, it is obvious that the arrangement according to the invention is not limited by the above-described exemplifying embodiments, but rather may be varied within the inventive spirit and scope of the appended claims. Hence, the method according to the invention is applicable to both horizontal and vertical pressure filter constructions utilizing filter cake pressing by a squeezing diaphragm. Respectively, diaphragm squeeze can be accomplished using any pressurized medium, the most typical being compressed air or water, and even by mechanical means. The pressurized gas used in the final drying of the filter cake may be any type of gas applied at elevated pressure. Also the filter cake washing liquid can be any kind of liquid or even steam that is considered most compatible with the overall process.

To a person versed in the art, it is also obvious that any conventional kind of valves and control systems can be used in the pressure filter controlled in accordance with the present method. Similarly, the on/off valves may be replaced by control valves or a parallel set of small valves for equalization of pressure differentials. In the control of pressure levels in the liquid piping, also feed pump speed control by means of a frequency converter, variator drive or the like means is a feasible technique of adjusting pressure levels to take place at a desired rate of pressure rise/fall.

The most significant feature of the present method and apparatus implementing the method is that the formation of the filter cake during the filtration step is controlled by adjusting the squeeze pressure imposed on the cake during the cake squeeze phase.

What is claimed is:

1. A method for controlling the formation of a filter cake (23) particularly in a filter chamber (14) of a pressure filter, **characterized** in that the formation of the filter cake during filtration is controlled by adjusting the squeeze pressure applied to the cake.

2. The method of claim 1, **characterized** in that the formation of the filter cake (23) during filtration is controlled by applying the cake squeeze pressure continually at a given pressure level throughout the entire filtration phase.

3. The method of claim 1 or 2, **characterized** in that the formation of the filter cake (23) during filtration is controlled by applying the cake squeeze pressure continually from the diaphragm squeeze phase up to the end of the cake drying phase.

4. The method of claims 1 - 3, **characterized** in that the method utilizes controlled pressure in the filter chamber (14) for controlling the squeeze pressure applied to the filter cake (23).

5. The method of claims 1 - 4, **characterized** in that the squeeze pressure is adjusted so as to control the different properties of the filter cake (23), particularly to eliminate the cracking tendency of the cake.

6. The method of claims 1 - 5, **characterized** in that the cake squeeze pressure is comprised of mechanical compression, pressurized gas medium such a compressed air and/or squeeze pressure exerted by a pressurized liquid that are substantially applied to the filter cake (23).

7. The method of claims 1 - 6, **characterized** in that the mechanical compression applied to the filter cake (23) is removed in a controlled fashion by virtue of continually maintaining the filter chamber (14) at an elevated pressure with the help of a pressurized gas and/or liquid medium that serves as squeeze pressure.

8. An apparatus for controlling the formation of a filter cake (23) particularly in a

filter chamber (14) of a pressure filter, **characterized** in that the pressure filter includes means capable of controlling the formation of the filter cake during filtration by virtue of adjusting the squeeze pressure applied to the cake.

9. The apparatus of claim 8, **characterized** in that the pressure filter includes means for controlling the formation of the filter cake (23) during filtration by way of controlledly applying the cake squeeze pressure continually from the diaphragm squeeze phase up to the end of the cake drying phase.

10. The apparatus of claim 8 or 9, **characterized** in that the valve system of the apparatus is used so that the pressure in the filter chamber (14) is adjusted for controlling the squeeze pressure applied to the filter cake (23).

11. The apparatus of claims 8 - 10, **characterized** in that the valve system of the apparatus is used so that the mechanical compression applied to the filter cake (23) is removed in a controlled fashion by virtue of continually maintaining the filter chamber (14) at an elevated pressure with the help of a pressurized gas and/or liquid medium that serves as squeeze pressure.

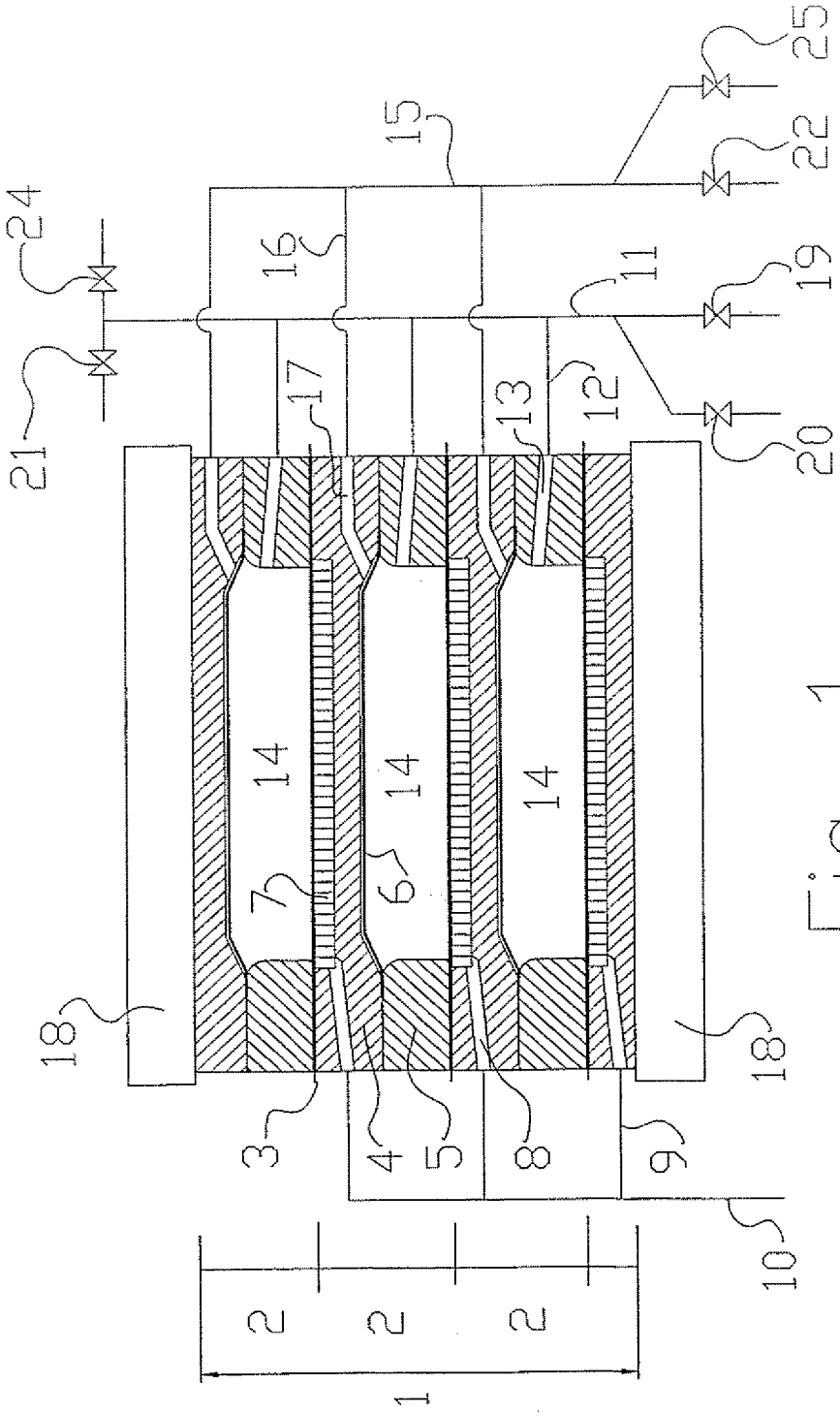

Fig. 1

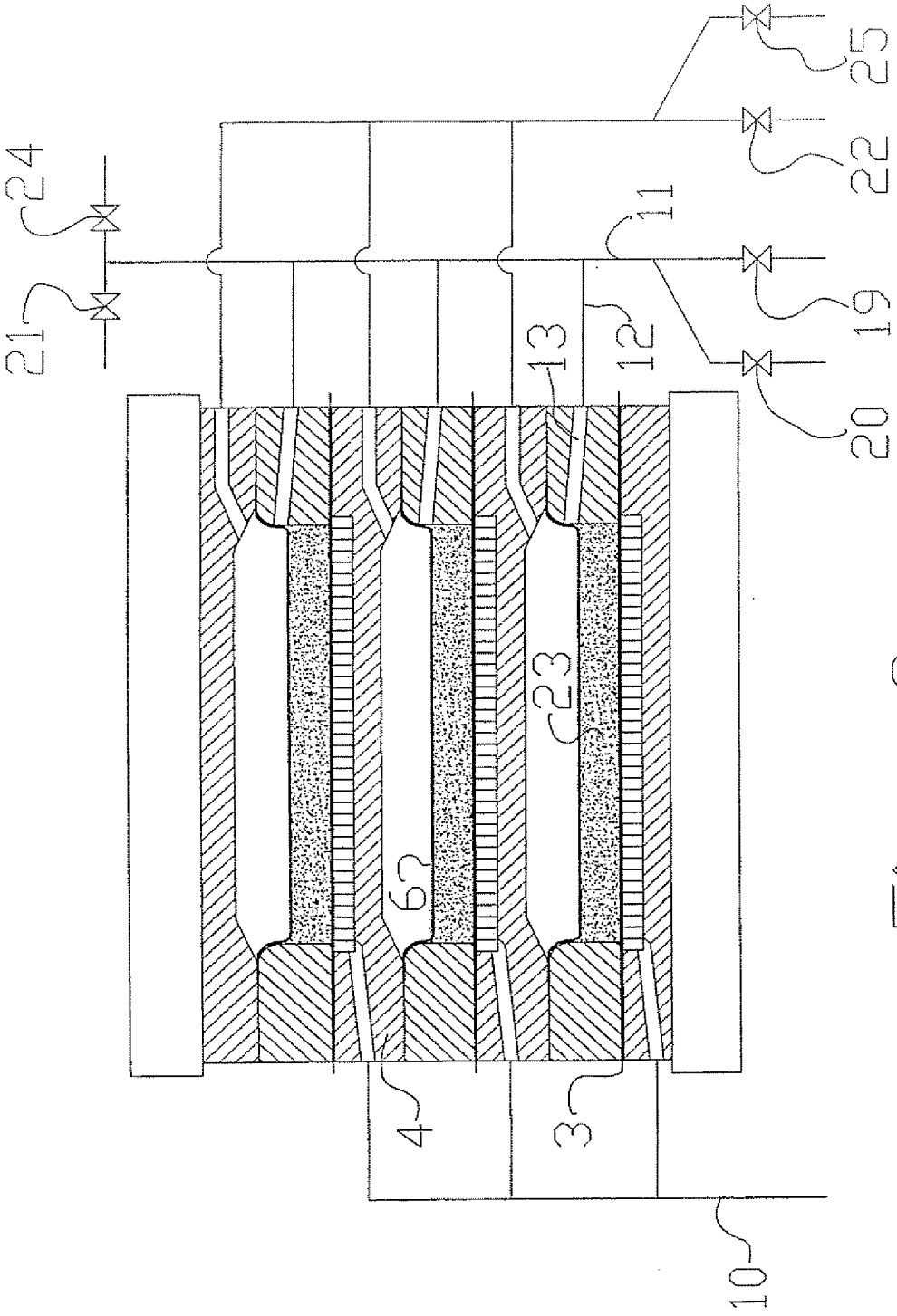

Fig. 2

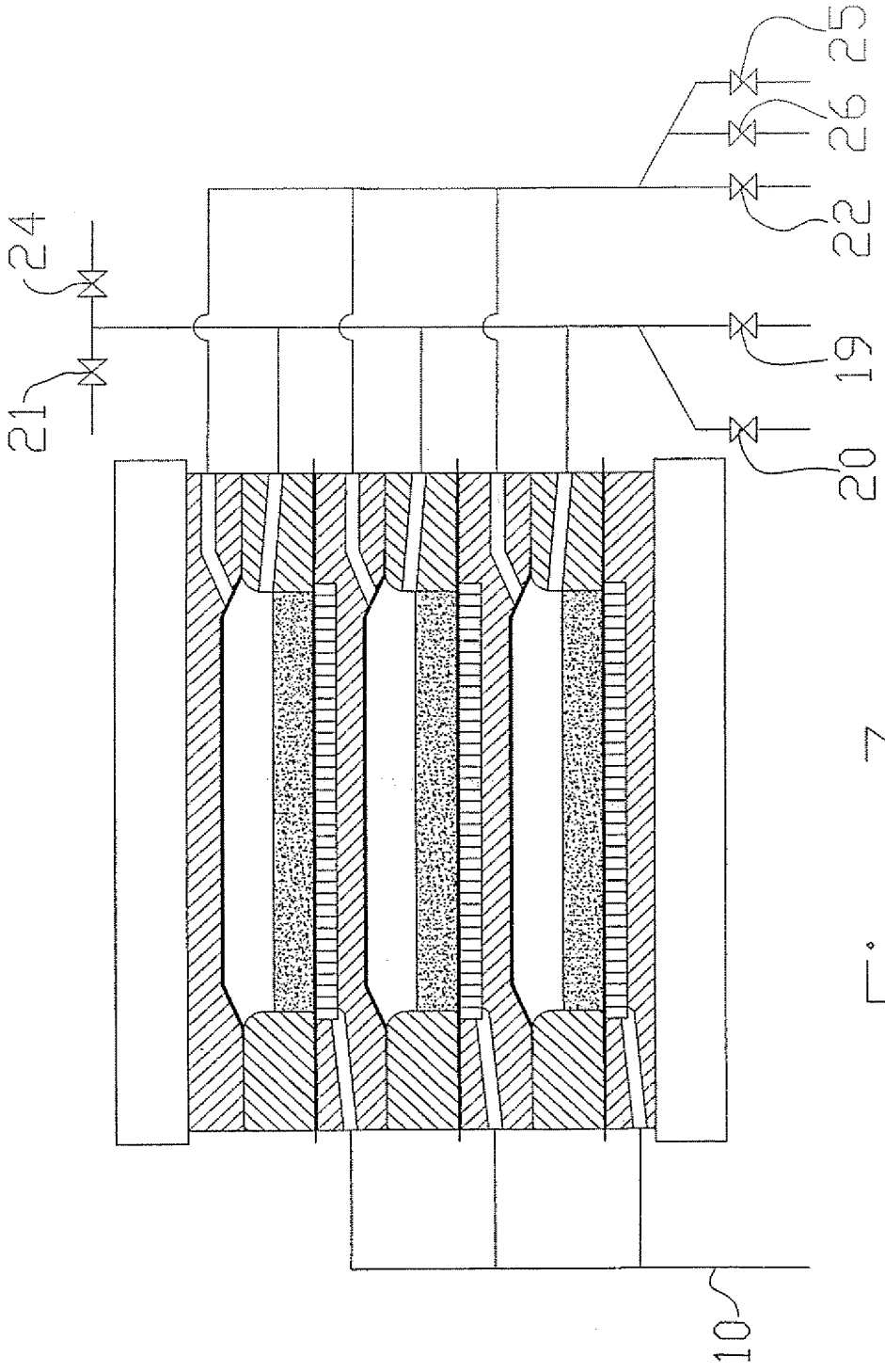

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 03/00009

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B01D 25/12
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 19637981 C1 (EBERHARD HOESCH & SÖHNE GMBH), 11 December 1997 (11.12.97) --	1-11
X	US 20010003330 A1 (REINHARD BOTT ET AL), 14 June 2001 (14.06.01) --	1-11
A	DE 3609564 A1 (GEBRÜDER NETZSCH MASCHINENFABRIK GMBH & CO), 19 June 1987 (19.06.87) --	1-11

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 April 2003	17 -04- 2003
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Jan Carlerud/ELY Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

Information on patent family members

29/03/03

International application No.
PCT/FI 03/00009

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 19637981 C1	11/12/97	NONE	
US 20010003330 A1	14/06/01	NONE	
DE 3609564 A1	19/06/87	NONE	